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Science Brief for Resource Managers

Metacommunity Dynamics of Gila River Fishes

Description

The upper Gila River in New Mexico is one of the few unobstructed rivers in the Colorado River Basin with largely intact native fish populations, including four federally listed and one state listed species.

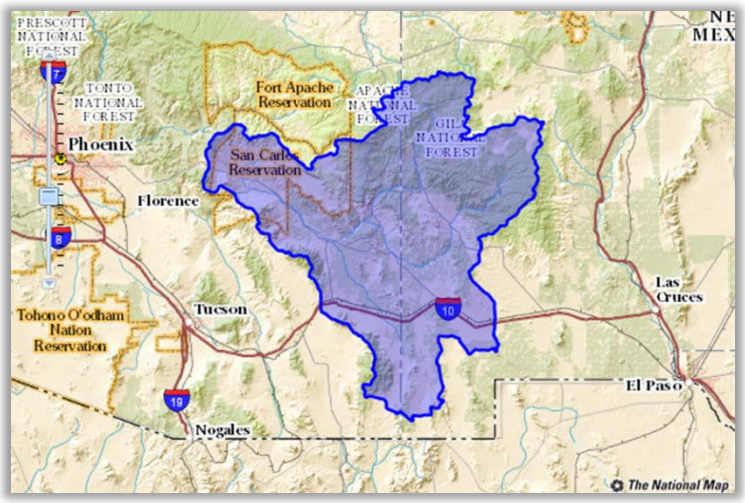
Freshwater systems throughout the West continue to be threatened by human encroachment and water development. Methodologies or decision support tools to evaluate resource management practices that foster an understanding of how fish species adapt to the effects of climate change are critical to future resource management planning.

Researchers recently investigated how the connectivity of the Gila River habitat impacts the behavior of native and non-native fish species. Understanding the factors that allow the native species to endure despite the threats of predation by nonnatives, habitat fragmentation, and increased disturbances associated with climate change can provide a general framework for future conservation actions.

The principles of metacommunity theory were particularly useful for understanding how the complex spatial structure of stream networks contributes to local and regional fish community dynamics. Because fragmentation and interactions with nonnative species are the leading causes of declines in native fishes in dryland rivers, insights into these interrelationships are essential to productive conservation decisions.

Sixteen sites in the upper Gila River Basin were selected to evaluate native and nonnative metapopulation dynamics. The primary objectives were to:

- Test the relative importance of dispersal factors, spatial factors, habitat, and biotic interactions on metacommunity dynamics.



Project Area

- Evaluate dispersal pattern variations of species having different life history strategies.
- Develop a predictive model for conservation of native fish communities in fragmented stream networks.

This study responds to goals identified by the Desert LCC partnership, including:

- Project the resiliency and vulnerability of natural or cultural resources in a changing climate.
- Assess and evaluate natural or cultural resources management practices and adaptation opportunities.

Management Implications

Metacommunity analysis indicated that fish communities are arranged along habitat gradients and in varied stream sizes, but that native and nonnative species have different responses to the gradients. Native species have source populations in both mainstem reaches (e.g., loach minnow and spikedace)

and tributaries (e.g., speckled dace and headwater chub). Other natives, such as longfin dace and the two native sucker species are more ubiquitous. When viewed across species, data suggest that maintaining a variety of habitats within the Gila River is necessary for maintenance of the entire native community.

Patterns of genetic structure supplemented by movement data also provided insights into the importance of dispersal among habitats. The two sucker species appear to have high rates of gene flow and disperse broadly among habitats in the upper Gila River with, at least for the desert sucker, upstream reaches potentially acting as source populations. Other native species have more limited dispersal along the mainstem, such as spikedace and loach minnow, which are potentially more vulnerable to population declines associated with disturbances. Finally, speckled dace have genetically distinct populations in headwaters that are separated by large spans of mainstem habitat, resulting in loss of genetic diversity.

Bayesian networks (graphical models demonstrating probabilistic relationships among variables) developed for this project illustrate potentially important associations among environmental factors and the persistence of two federally endangered fish species. This network approach incorporates information from multiple sources, including empirical data, expert opinion, and model output. Uncertainty resulting from any of those sources can be integrated directly into the networks to aid in management decision making. This results in an adaptable framework for predicting how probabilities of occurrence might be influenced by management actions (e.g., nonnative removal), natural disturbances (e.g., wildfire), or habitat alteration (e.g., fragmentation).

The resulting network from this study supports conclusions from community monitoring and genetic studies, indicating that both spatial heterogeneity of source populations and dispersal processes should be maintained. Additionally, modifications that block migration or benefit nonnative fishes are likely to have a negative influence on native fishes in this system.

Future Direction

The ability to classify species with vastly different conservation status levels (e.g., threatened, stable, and nonnative) based on key life history traits can aid in developing management strategies and evaluating the effectiveness of efforts to control nonnative predators (e.g., construction of barriers and predator removals).

The approach used in this project to develop a spatially-explicit conservation decision support tool could help identify at-risk habitats, assess the potential effects of management actions on those habitats, and anticipate the impacts to desert fish communities.

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Progress to Date

This study is complete. More information can be found at **https://www.sciencebase.gov/catalog/item/53225721e4b0af5da0bcb492**.

Longfin dace, photo credit: Madrean Archipelago Biodiversity Assessment Observations, J.C. Rorabaugh